Report of Agronomic Trials

1996B

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Contents

Summary

This report is an internal document in which all data recorded and their analysis is given in full detail. It will constitute a clear memory of the work done on maize agronomy in 1996B.

During the 1996 B cropping season, six agronomy trials have been conducted in three locations: Carimagua, La Libertad (Meta) and Pescador (Cauca). At Carimagua, residual effects of Sulcamag amendments and PxK applications have been recorded. At La Libertad and Pescador, two trials have been repeated; one to compare effects of various amendments containing sulfur and a second one to draw Sikuani's curve of yield response to increased of density, and to study the production of dry matter, thinking in a possible use as a forage crop.

At Carimagua, trials did not received any fertilizer, then nitrogen would have been the limiting factor. Yields are low (2 t/ha). Meanwhile, significant differences between treatments have been recorded, which confirmed results of the 1995 B season.
At La Libertad, trials were sown late due to delays to organize this first season. They consequently have suffered drought at flowering time. However, they gave useful information, mainly the trial on amendments.
At Pescador, rains came late this year, and the density trial suffered drought during the first weeks. On the other hand, trials were conducted on farmers fields, in a mountainous sloppy area. Soils were heterogeneous and more fertile than it was expected. Recorded data could not be statistically discriminated.

The main conclusions are:

- Confirmation of the important positive effect of sulfur containing amendments, at Carimagua and La Libertad. Sulfur strongly increases plant growth and grain yield. Soil analysis at La Libertad show that sulfur migrates with calcium and magnesium to the 20-40 cm layer. On the other hand, mineral sulfur have a positive effect on phosphorus availability in soil.

- Sikuani can produce 5 t/ha in the Pescador area, at 1850 masl during the second yearly cropping season. The variety showed symptoms of turcicum blight, but disease pressure is generaly low during this cropping season.

- Phosphorus is a main limiting factor at Carimagua, more than potassium. Residual effect of phosphorus application remains important.

1. Response of Sikuani to two amendments and five methods of application
Carimagua 1996 B

Objective: To measure residual effect of amendments applied the previous year(1995). Two amendments were compared with five methods of application.

Treatments:

a. Two amendments: 1 - Dolomite 57% $CaCO_3$, 35% $MgCO_3$ 1.03 t/ha to reduce the Al saturation to 55%
2 - Sulcamag® 25% CaO, 13% MgO, 8% S 1.30 t/ha
Sulcamag is produced by an acidic treatment of dolomite with sulfuric acid.

b . Five methods of application: 1 - Broadcasting, 30 days before planting
2 - Band application, at planting time
3 - Hill placement, at planting time
4 - Broadcasting of half-dose and band application of the remaining half-dose
5 - Broadcasting of half-dose of one amendment and band application of half-dose of the other amendment

c. Variety: Sikuani

Trial management:
Design: Split-plot with application methods as main, and amendments as subblocks
Replications : 3
Plot size: 5 lines 10 m long, 2 rows were harvested (15.75 m^2)
Sowing distances: 0.75 x 0.50 m, 2 plants per hill. Expected plant number: 84
N,P,K: 120,80,80 in 1995, none in 1996
Sowing date: August 7, 1996
Harvest date: December 5, 1996

Seasonal meteorology:

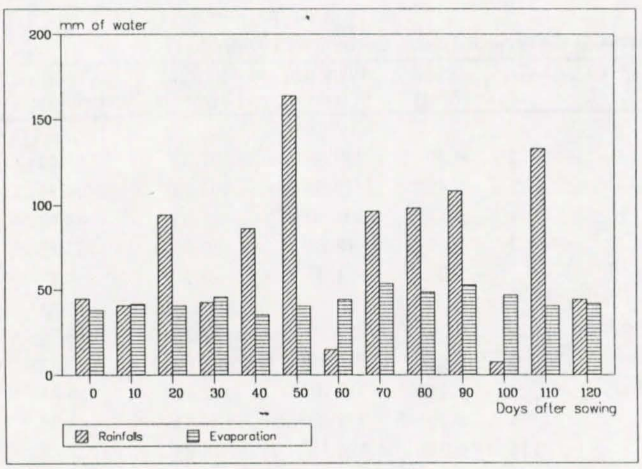

Fig. 1: Ten day record of rainfall and evaporation, during the growing period

Results:

Table 1: Means of the 10 treatments. Carimagua 1996B.

Amendment	Application method	Yield (t/ha)	Plant hgt (cm)	Ear hgt (cm)	Plants number	Ears/plant
Dolomite	Hill placement	0.956	158	57	64	0.75
	Broadcast	0.756	193	75	70	0.75
	Band placement	0.785	177	60	69	0.74
	Broadcast + band	0.866	165	53	65	0.75
	Broad + band with change	1.34	203	73	74	0.93
Sulcamag	Hill placement	1.411	215	73	72	0.92
	Broadcast	1.297	203	78	73	0.90
	Band placement	1.242	196	65	73	0.90
	Broadcast + band	1.625	190	62	66	0.91
	Broad + band with change	1.36	198	77	72	0.98

Table 2: Means for amendments and methods of application. Carimagua 1996B.

	Yield (t/ha)	Plant hgt (cm)	Ear hgt (cm)	Plants number	Ears/plant
Amendments					
Dolomite	0.94 b	179.33 b	63.67	68.33	0.78 b
Sulcamag	1.39 a	200.67 a	71.00	71.27	0.93 a
Application method					
Hill placement	1.18 ab	186.67	65.00 abc	68.17	0.83 b
Broadcast	1.03 b	198.33	76.67 a	71.33	0.83 b
Band placement	1.01 b	186.67	62.50 bc	71.00	0.82 b
Broadcast + band	1.25 ab	177.5	57.50 c	65.67	0.83 b
Broad + band with change	1.35 a	200.83	75.00 ab	72.83	0.95 a

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares of the recorded data. Carimagua 1996B.

Source	df	Yield (t/ha)	Plant hgt (cm)	Ear hgt (cm)	Plants number	Ears/plant
Total sub-block	5	0.39	730.00	107.33	43.52	0.03
Amendments	1	1.49*	3413.33**	403.33	64.53	0.16*
Blocks	1	0.14	107.50	15.83	44.40	0.00
Pooled Error 1	2	0.09	10.83	50.83	32.13	0.01
C.V. %		25.2	1.7	10.6	8.1	8.9
Total	29	0.12	413.79	120.23	36.10	0.01
Methods	4	0.12*	547.92*	407.08*	49.12	0.02*
Amendments x Methods	4	0.11*	728.08*	47.08	19.95	0.00
Total sub-blocks	5	0.39***F	730.00*	107.33	43.52	0.03**
Pooled Error 2	16	0.03	189.38	70.83	34.56	0.01
C.V. %		15.1	7.2	12.5	8.4	8.3

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

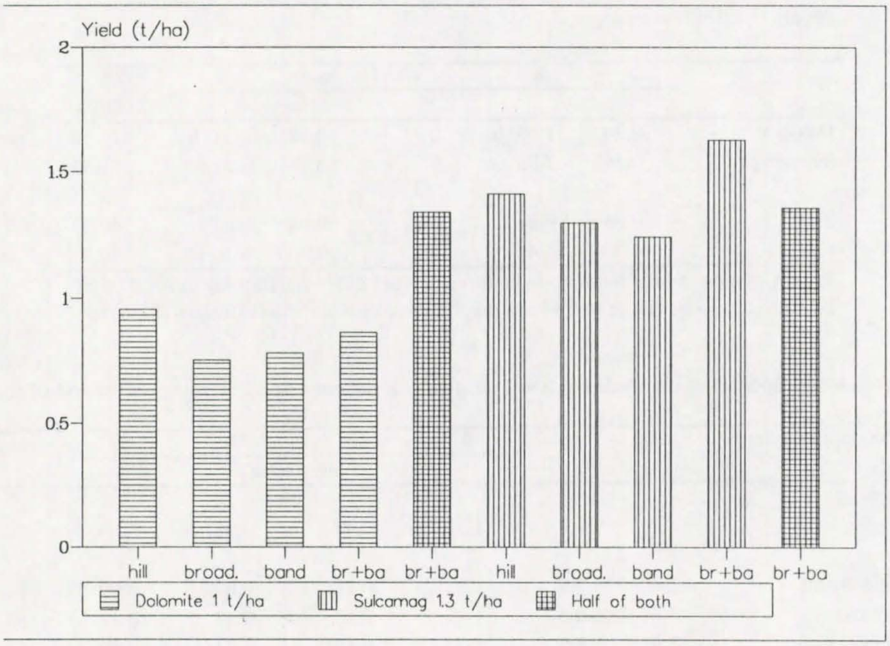

Fig. 2: Average yields of Sikuani for each residual treatment. Carimagua 1996 B.

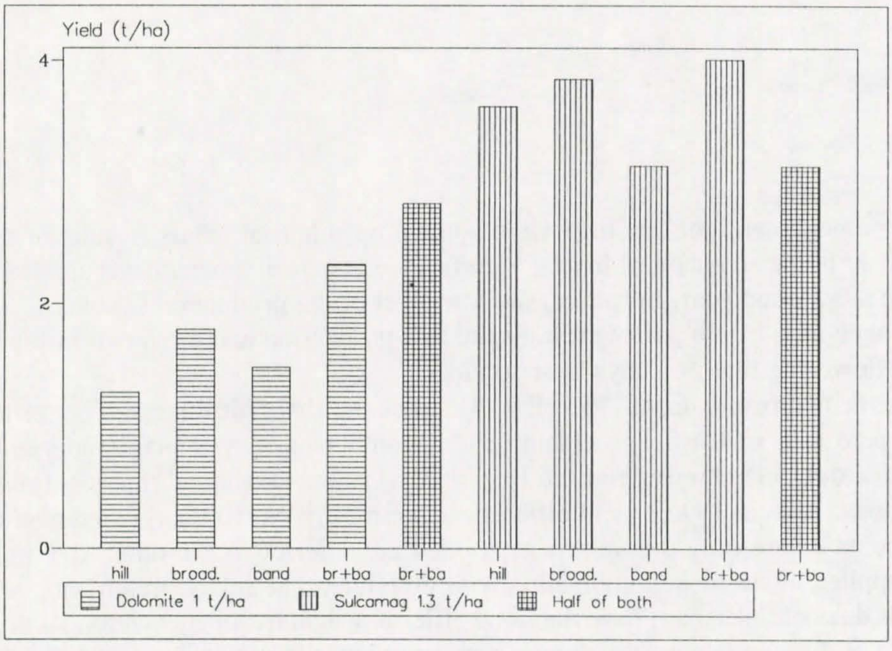

Fig. 3: Average yield of Sikuani for each treatment. Carimagua 1995 B.

Table 4: chemical analysis of ear leaves from broadcasted plots. Carimagua 1996B.

	P	K	Ca	Mg	S	Al
			%			ppm
Dolomite	0.26	1.66 b	0.25 b	0.22	0.11 b	113.50
Sulcamag	0.19	2.05 a	0.37 a	0.26	0.22 a	56.33
S.D.	0.03	0.04	0.02	0.04	0.01	46.29
C.V. %	14.7	2.4	6.60	15.40	6.50	54.5

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 5: Changes of chemical properties of the Carimagua soil treated with dolomite and Sulcamag, at the end of the 1995 B season.

Amendment	Method of application	pH	P ppm Bray II	Al	Ca	Mg	K	Al sat. %	S ppm
					meq/100g				
Original Soil		4.7	1.8	1.57	0.17	0.03	0.04	86.74	-
Dolomite	Hill placement.	3.4	7.9	1.82	0.26	0.09	0.09	80.98	23.77
	Broadcast	3.7	6.3	1.45	0.43	0.23	0.11	66.34	20.13
	Band placement	3.8	4.5	1.22	0.65	0.33	0.09	53.46	19.31
	Band + Broadcast	3.6	5.3	1.62	0.44	0.21	0.09	68.58	19.43
	Broad. + Sulca. band	4.1	5.4	1.11	0.76	0.41	0.08	47.79	60.53
Sulcamag	Hill placement.	3.8	7.5	1.42	1.14	0.31	0.09	52.92	90.43
	Broadcast	3.8	5.8	1.55	0.46	0.22	0.08	67.36	39.77
	Band placement	4.1	6.5	1.24	0.92	0.46	0.08	46.18	94.41
	Band + Broadcast	3.8	5.5	1.41	0.63	0.33	0.08	57.87	61.93
	Broad. + Sulca. band	3.9	5.8	1.42	0.51	0.22	0.09	63.63	30.31

Discussion:

In 1996, neither amendment nor fertilizer were applied on this trial. Thus, results of this season are a residual effect study of the all chemical inputs. Significative effects of amendments applied in 1995 are still registered during this second year, in spite of the low level of the production (Tables 1, 2 and 3, Fig. 2). The lack of nitrogen application partly explains the low production and as shown in Fig. 1 due to water shortage during flowering time, 60 days after sowing.
Data of 1996 confirmed results from 1995 (Fig. 3) indicating that Sulcamag is a better amendment than dolomite in the acid soils of Carimagua.Plant height, number of ear per plant and yield of the Sikuani variety are significantly increased. After the first season, it was concluded that yield did not depend on application methods. Also in 1996B yield differences are mostly due to the amendment effects (Fig. 2). The four treatments where only dolomite was applied are inferior to the other six treatments, where Sulcamag was applied alone or in combination with dolomite. The mixed treatments, with half dose of dolomite and half dose of Sulcamag, have the same efficiency than treatments with total dose of Sulcamag. This is the reason of the significative differences registered in the ANOVA for methods of application and amendments x methods interaction (Tables 2 and 3).

Chemical analysis was done on ear leaves from plants where the broadcast method was used (Table 4). Leaves from plants grown in plots amended with Sulcamag contained a higher concentration of potassium, calcium and sulfur, compared to dolomite amendment. Their aluminium concentration is half of the check, but this result is not statistically significant, due to the great variability of this data (C.V. = 54.5%).

In conclusion, sulfates contained in Sulcamag have a strong effect on the maize growth and yield at Carimagua. These sulfates can act in two ways: (1) Correcting sulfur deficiency often reported in these soils. Soil analysis made after the cultivation of 1995 showed that sulfur content of soil increased from 20 ppm in plots treated with dolomite to 70 ppm in plots treated with Sulcamag (Table 5). (2) Deeper correction of soil acidity and cations deficiency by coleaching of soluble and neutral cations-sulfate salts in deeper layers.

Effect of some amendments on maize production.
La Libertad Villavicencio, Meta, 1996B

Objectives: First results obtained in Carimagua and La Libertad in 1995 showed the advantage of using Sulcamag against dolomite as amendment in the acid soils of these two Centers. To understand the effect of sulfur in these results, various sulfate and sulfur sources were tested.
The trial was also planned to study the effect of amendment levels and application methods.

Treatments:

Amendments:	Check		
	Sulfur	100% S	152 kg/ha
	Dolomite	57% $CACO_3$, 35% $MgCO_3$	1.5 t/ha
	Dolomite + sulfur	"	1.5 t/ha + 152 kg/ha
	Sucromac®	21% CaO, 8% MgO, 11% SO_4, 15% M.O.	2.46 t/ha
	Sulcamag®	25% CaO, 13% MgO, 8% S	1.90 t/ha

Dolomite dose of 1.5 t/ha was decided before the soil analysis results were available. This dose was expected to decrease the aluminum saturation to level between 50 and 60 % . Sucromac and Sulcamag doses was calculated to bring an uniform Ca + Mg value per treatment. Sulfur dose was calculated to supply as much sulfur as in the Sulcamag treatment.
Sucromac contains gypsum, calcium and magnesium acids and concentrated sugarcane juice. Organic matter of the product is mainly composed of saccharose and caramel polymers.
Sulcamag is produced by an acidic treatment of dolomite with sulfuric acid.

Application methods: . broadcast, at complete and half doses
. band application, at one fourth and one eighth doses

Trial management:

Design: Split-plot with products as main, and application methods in sub-blocks.
Replications: 3
Plot size: 5 lines of 5 meters, from which the 3 central lines were harvested (12.375 m^2)
Sowing distances: 0.75 x 0.50 m. 2 plants/ hill. Expected plants number: 66
Maize variety: Sikuani
Fertilizers: N,P,K: 0,60,55, as urea, TSP and KCl
Sowing date: October 21, 1996
Harvest date: February 18, 1997

Seasonal meteorology:

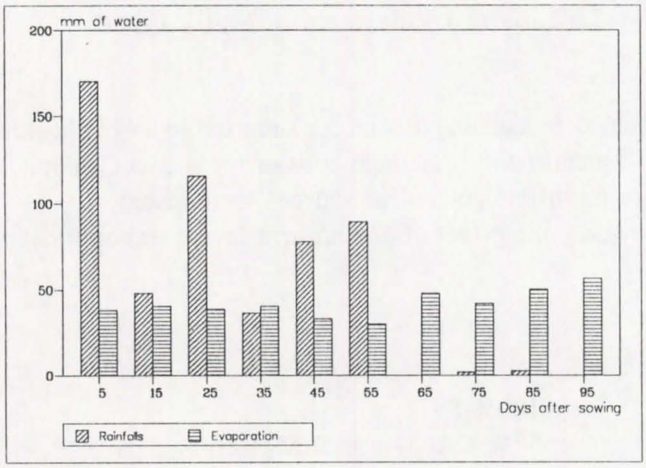

Fig. 1: Ten day record of rainfall and evaporation, during the growing period

Results:

Table 1: Average data for each treatment

	Yield (t/ha)	Male flowering (DAS)	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plant
Broadcast amendments						
Check	1.09 b	60	183	88 ab	51	0.82
Sulfur, 1/2 dose	1.62 ab	61	188	92 ab	57	0.85
Sulfur , total dose	1.56 ab	60	192	92 ab	57	0.85
Dolomite, 1/2 dose	1.16 b	60	188	82 ab	54	0.82
Dolomite, tot. dose	1.28 b	62	182	77 b	54	0.86
Dolomite + Sulfur, 1/2 dose	1.52 ab	60	197	92 ab	57	0.81
Dolomite + Sulfur, tot. dose	1.63 ab	62	190	90 ab	54	0.91
Sucromac, 1/2 dose	1.92 a	61	200	97 a	56	0.92
Sucromac, tot. dose	2.04 a	61	197	93 ab	57	0.94
Sulcamag, 1/2 dose	2.00 a	62	197	93 ab	58	0.86
Sulcamag, tot. dose	2.02 a	60	205	95 ab	56	0.89
Band placed amendments						
Check	1.59	60	192	92	59	0.88
Sulfur, 1/8 dose	1.29	60	187	85	50	0.92
Sulfur , 1/4 dose	1.29	60	188	83	56	0.86
Dolomite, 1/8 dose	1.21	61	182	80	54	0.85
Dolomite, 1/4 dose	1.45	62	187	90	57	0.82
Dolomite + Sulfur, 1/8 dose	1.60	60	192	88	58	0.91
Dolomite + Sulfur, 1/4 dose	1.28	61	185	87	55	0.79
Sucromac, 1/8 dose	1.41	60	182	83	52	0.90
Sucromac, 1/4 dose	1.35	61	192	90	56	0.80
Sulcamag, 1/8 dose	1.23	61	178	82	55	0.81
Sulcamag, 1/4 dose	1.66	60	195	93	59	0.90

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 2: Mean squares for recorded data in broadcast and band placed treatments. Trial is analyzed as two trials of three repetitions randomized design. mLa libertad 1996 B.

Source	df	Yield (t/ha)	Male flowering (days)	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ear/plant
Broadcast treatments							
Total	32	0.15	1.22	104.88	64.06	12.32	0.00
Amendments	10	0.36***	1.89	152.27	105.00*	11.29	0.01
Reps	2	0.06	0.27	82.58	43.18	63.85*	0.01
Pooled error	20	0.06	0.97	83.41	45.68	9.28	0.00
CV %		14.5	1.6	4.7	7.5	5.5	7.3
Band placed treatments							
Total	32	0.10	1.19	109.42	66.67	17.04	0.01
Amendments	10	0.00	1.35	80.15	56.67	23.40	0.01
Reps	2	0.12	0.27	203.03	46.21	7.85	0.01
Pooled error	20	0.11	1.21	114.70	73.71	14.78	0.01
CV %		23.6	1.8	5.7	9.9	6.9	10.7

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Table 3: Soil analysis before planting. La Libertad 1996B.

Depth (cm)	% M.O.	ppm P Bray II	pH	milliequivalent / 100 g				Al saturation	ppm
				Al	Ca	Mg	K	%	S
0-20	4.3	10.8	4.2	2.44	0.58	0.30	0.14	71	6.7
20-40	3.6	2.8	4.1	2.79	0.35	0.13	0.07	84	3.4

Table 4: Analysis of ear leaves from plots broadcasted with total dose of amendments. La libertad 1996B.

	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Al (ppm)
Check	0.19	2.13	0.29 b	0.13 b	0.22	113
Sulfur	0.22	2.33	0.32 ab	0.13 b	0.21	104
Dolomite	0.23	2.23	0.38 a	0.19 a	0.23	156
Dolomite + Sulfur	0.22	2.42	0.37 a	0.19 a	0.21	133
Sucromac	0.19	2.44	0.34 ab	0.19 a	0.24	111
Sulcamag	0.21	2.29	0.34 ab	0.16 ab	0.25	156
S.D.	0.03	0.16	0.03	0.02	0.03	35.94
CV %	11.9	7.1	8.2	11.1	12.2	27.9

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 5: Means of soil analysis data. Samples were taken in plots treated with full dose broadcast treatment. La Libertad 1996B.

	P	Al	Ca	Mg	K	∑ cations	Al sat	S
	ppm	meq / 100 g					%	ppm
0-20 cm								
Check	9.80	2.54 a	0.57 b	0.22 c	0.11 b	3.43 ab	74.00 a	20.47 c
Sulfur	12.17	2.42 a	0.65 b	0.23 c	0.11 b	3.41 ab	71.17 a	31.70 c
Dolomite	9.80	2.16 b	0.81 ab	0.31 bc	0.10 b	3.38 b	63.90 ab	20.00 c
Dol + Sulfur	12.07	2.09 b	0.99 a	0.46 a	0.12 b	3.66 a	56.84 b	52.23 a
Sucromac	10.23	2.28 ab	0.81 ab	0.33 bc	0.11 b	3.53 ab	64.43 ab	35.63 abc
Sulcamag	9.10	2.20 b	0.75 ab	0.39 ab	0.15 a	3.49 ab	62.88 ab	46.00 ab
Contrasts								
Sulfur (2)	12.12 a							
Others (4)	9.73 b							
20 -40 cm								
Check	3.77	2.62 a	0.42 b	0.13 a	0.06	3.23	80.86 a	17.83 b
Sulfur	5.40	2.63 a	0.41 b	0.12 a	0.07	3.23	81.28 a	24.63 ab
Dolomite	4.07	2.44 a	0.45 ab	0.15 a	0.07	3.12	78.27 a	16.80 b
Dol + Sulfur	4.60	2.39 a	0.58 a	0.23 a	0.08	3.28	73.00 a	32.33 a
Sucromac	4.33	2.60 a	0.46 ab	0.15 a	0.07	3.29	79.05 a	26.33 ab
Sulcamag	3.63	2.42 a	0.49 ab	0.24 a	0.08	3.22	74.97 a	28.67 a
Contrasts								
Sulfur (2)	5.00 a							
Others (4)	3.95 b							

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 6: Mean squares for data of soil analysis made in plots treated with full dose broadcast amendments. La Libertad 1996B.

Source	df	P	Al	Ca	Mg	K	∑ cations	Al sat	S
0-20 cm									
Total	17	275	8	3	1	0	5	5394	18819
Amendments	5	494	0.09*	0.07*	0.03***	0.00**	0.03*	11394**	51772**
Sulfur	1	22.72**							
Reps	2	96	0.34***	2	0	0	0.26***	6687	1965
Pooled error	10	201	2	2	0	0	1	2138	5713
CV %		135	59	163	162	121	27	71	220
20-40 cm									
Total	17	0.78	0.06	0.01	0.00	0.00	0.05	17.97	45.72
Amendments	5	1.25	0.04*	0.01*	0.01*	0.00	0.01	32.56*	111.49**
Sulfur	1	4.41*							
Reps	2	0.09	0.36***	0.00	0.00	0.00	0.31***	25.79	29.97
Pooled error	10	0.68	0.01	0.00	0.00	0.00	0.01	9.12	15.99
CV %		19.2	4.2	11.6	28.0	14.4	3.2	3.9	16.4

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

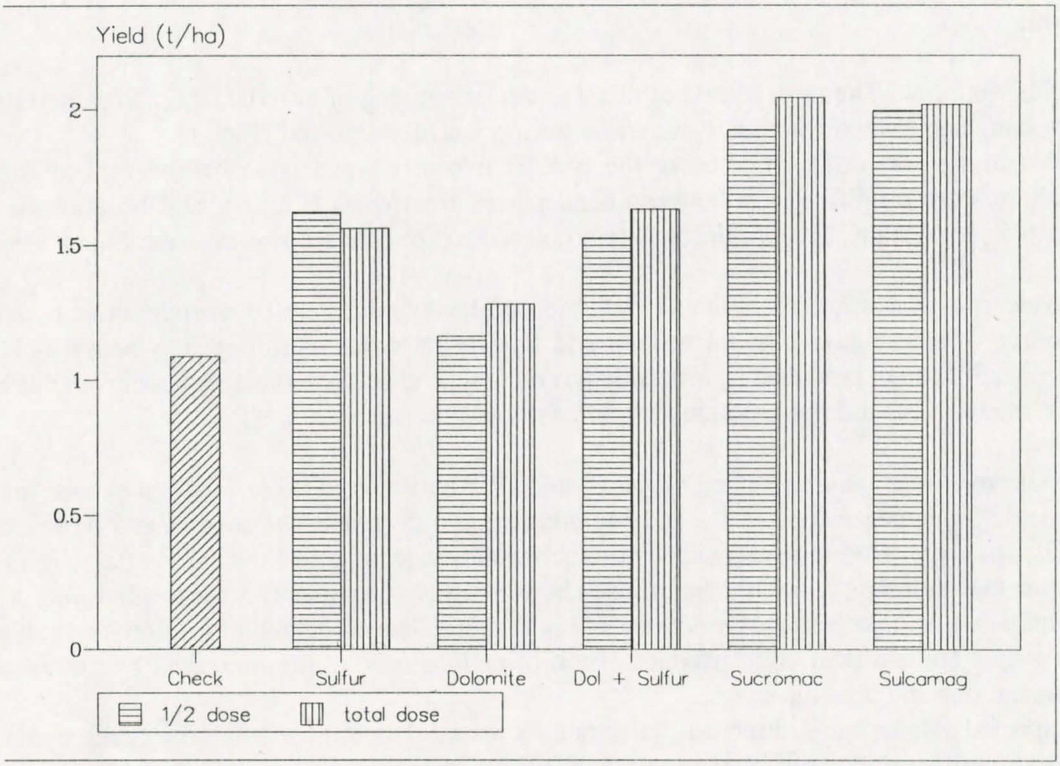

Fig. 2: Average yield of broadcasted treatments. La Libertad 1996B.

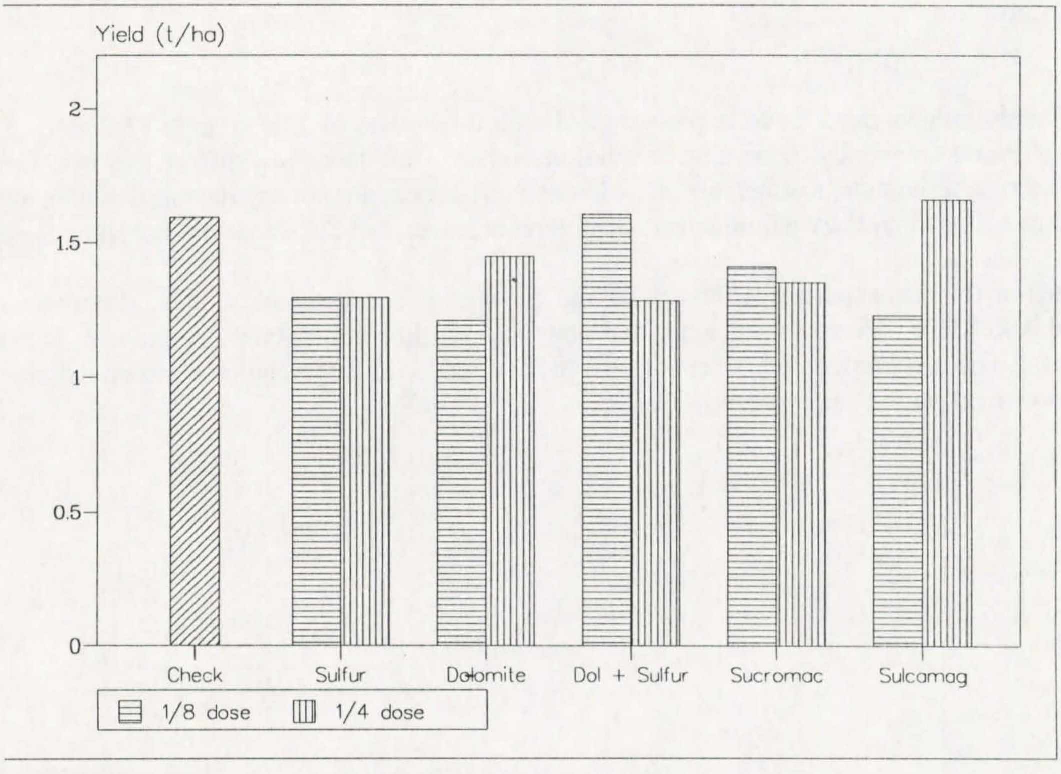

Fig. 3: Average yield of band placed treatments. La Libertad 1996B.

Discussion:

Grain yields were low. The main reason of this was the late sowing of the trial. Rainfall stopped at flowering time and plants had gone through a water stress during the filling period (Fig. 1).
Statistical analysis was done considering the trial as two different trials of three replications (Table 2) because there were no differences between band placed treatments (Fig. 3), and because the trial is not strictly a split-plot design, because doses in band placed treatments are less than the broadcasted ones.

In the broadcast treatments, ear height and yield are significantly different between treatments. Amendments with a source of sulfur gave a better growth and fertility of maize, resulting in a better yield (Table 1). Sucromac and Sulcamag produced significantly more than the check without amendments in this experiment. The other amendments did not produce a significant yield increase.

Soil analysis were done before planting (Table 3) and after harvesting (Table 5). Data shows that dolomite, Sucromac and Sulcamag increased Ca and Mg content, and decreased Al content and Al saturation in the upper 0-20 cm layer. Dolomite associated with sulfur and Sulcamag had the same effects in the 20-40 cm layer, but neither dolomite alone nor Sucromac showed any improvement in the lower layer. Amendments which contain sulfur increased sulfur content in both layers. The association of dolomite+sulfur increased more the sulfur content than other products. Sum of cations was a little increased by amendments which associating cations and a sulfur source.
Two unexpected effects were observed: Sulcamag increased potassium availability in the upper 0-20 layer and mineral sulfur increased phosphorus availability in both layers. These two results showed to be statistically significant.
From the soil analysis it can be concluded that Sulcamag and dolomite + sulfur corrected soil for Ca, Mg and Al content at a similar level, after harvest, meanwhile Sucromac effect is inferior. Al saturation levels in the 0-20 layer range now between 57 - 75 %. Important growth differences could be expected during the next cultivation.

Ear leaf analysis have been made in plots treated with total doses of amendments (Table 4). They do not show any mineral deficiency, according to usual references. But they show differences in concentration of calcium and magnesium due to amendments. Although differences are not significant, dolomite and Sulcamag amendments seems to increase aluminum concentration in leaves, but Sucromac did not show the same effect.

In conclusion, in this experiment Sucromac and Sulcamag increase yields over dolomite or dolomite associated with sulfur . However Sulcamag and dolomite + sulfur improved more the soil, in analysis done after harvest. The low productivity level of this trial have reduced discrimination between treatments. Results will be confirmed on the next cropping season.

2b. Effect of some amendments on maize production
Pescador, Cauca, 1996B

Objectives: First results obtained in Carimagua and La Libertad in 1995 showed the advantage of using Sulcamag against dolomite as amendments in the acid soils in these two Centers. To understand the effect of sulfur in these results, various sulfate and sulfur sources were tested.
The trial was also planned to study the effect of amendment levels and application methods.

Treatments:

Amendments:	Check		
	Sulfur	100% S	152 kg/ha
	Dolomite	57% $CACO_3$, 35% $MgCO_3$	1.5 t/ha
	Dolomite + sulfur	"	1.5 t/ha + 152 kg/ha
	Sucromac®	21% CaO, 8% MgO, 11% SO_4, 15% M.O.	2.46 t/ha
	Dolomite + gypsum		1.21 t/ha + 0.37 t/ha

Dolomite dose of 1.5 tons/ha was decided before the soil analysis results were available. Sucromac and dolomite + gypsum doses was calculated to bring an uniform Ca + Mg value per treatment. Sulfur dose was calculated to supply as much sulfur as in the Sulcamag treatment used at La Libertad.
Sucromac contains gypsum, calcium and magnesium acids and concentrated sugarcane juice. Organic matter of the product is mainly composed of saccharose and caramel polymers.
Gypsum applied is a residual product of chemical industry.

Application methods: . broadcast, at complete and half doses
. band application, at one fourth and one eighth doses

Trial management:

Design: Split-plot with products as main and application methods as sub-blocks.
Replications: 3
Plot size: 5 lines of 3.5 meters, from which the 3 central lines were harvested (10.5 m^2)
Sowing distances: 0.75 x 0.50 m. 2 plants/hill. Expected plants number: 42
Maize variety: Sikuani
Fertilizers: N,P,K: 90,20,50, applied as urea, TSP and KCl
Sowing date: October 21, 1996
Harvest date: February 18, 1997

Results:

Table 1: Soil analysis before planting. Pescador 1996B.

Plot situation	Depth (cm)	% M.O.	ppm P Bray II	pH	Al (meq/100gr)	Ca (meq/100gr)	Mg (meq/100gr)	K (meq/100gr)	Al sat. %	S ppm
Upper part	0-20	6.5	1.0	4.6	0.33	1.51	0.50	0.46	12	110.3
	20-40	3.0	0.48	4.5	0.32	0.88	0.26	0.17	20	52.8
Downer part	0-20	8.5	8.2	4.6	0.96	2.62	0.78	0.59	19	70.1
	20-40	5.25	3.8	4.5	1.48	1.94	0.62	0.36	34	71.5

Table 2: Average recorded data for each treatment. Pescador 1996B.

Treatments	Broadcast treatments			Treatments	Band placed treatments		
	Yield (t/ha)	Plants harvested	Ears/plant		Yield (t/ha)	Plants harvested	Ears/plant
Check	4.74	41	1.13	Check	5.50	41	1.14
Sulfur, 1/2 dose	4.80	38	1.13	Sulfur, 1/8 dose	5.89	39	1.21
Sulfur , total dose	5.61	36	1.27	Sulfur , 1/4 dose	5.40	38	1.17
Dolomite, 1/2 dose	4.19	37	1.07	Dolomite, 1/8 dose	5.37	39	1.16
Dolomite, tot. dose	4.78	37	1.04	Dolomite, 1/4 dose	5.16	40	1.11
Dolomite + Sulfur, 1/2 dose	4.63	38	1.12	Dolomite + Sulfur, 1/8 dose	5.51	40	1.24
Dolomite + Sulfur, tot. dose	4.66	38	1.08	Dolomite + Sulfur, 1/4 dose	5.82	39	1.36
Sucromac, 1/2 dose	5.79	40	1.21	Sucromac, 1/8 dose	5.93	42	1.14
Sucromac, tot. dose	5.95	38	1.29	Sucromac, 1/4 dose	5.46	40	1.04
Dolomite + Gypsum, 1/2 dose	4.43	40	1.03	Dolomite + Gypsum, 1/8 dose	4.78	40	1.08
Dolomite + Gypsum, tot. dose	5.13	39	1.16	Dolomite + Gypsum, 1/4 dose	5.38	42	1.17

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares for recorded data in broadcast and band placed treatments. The trial is analyzed as two trials of three randomized repetitions. Pescador 1996B.

Source	df	Broadcast treatments			Band placed treatments		
		Yield (t/ha)	Plants harvested	Ears/plant	Yield (t/ha)	Plants harvested	Ears/plant
Total	32	1.32	12.63	0.03	1.05	2.81	0.02
Amendments	10	0.99	6.63	0.02	0.33	3.87	0.02
blocks	2	2.46	58.45**	0.02	7.31***	0.82	0.04
Pooled error	20	1.37	11.52	0.03	0.78	2.48	0.01
C.V. %		23.5	8.8	15.2	16.2	3.9	8.7

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

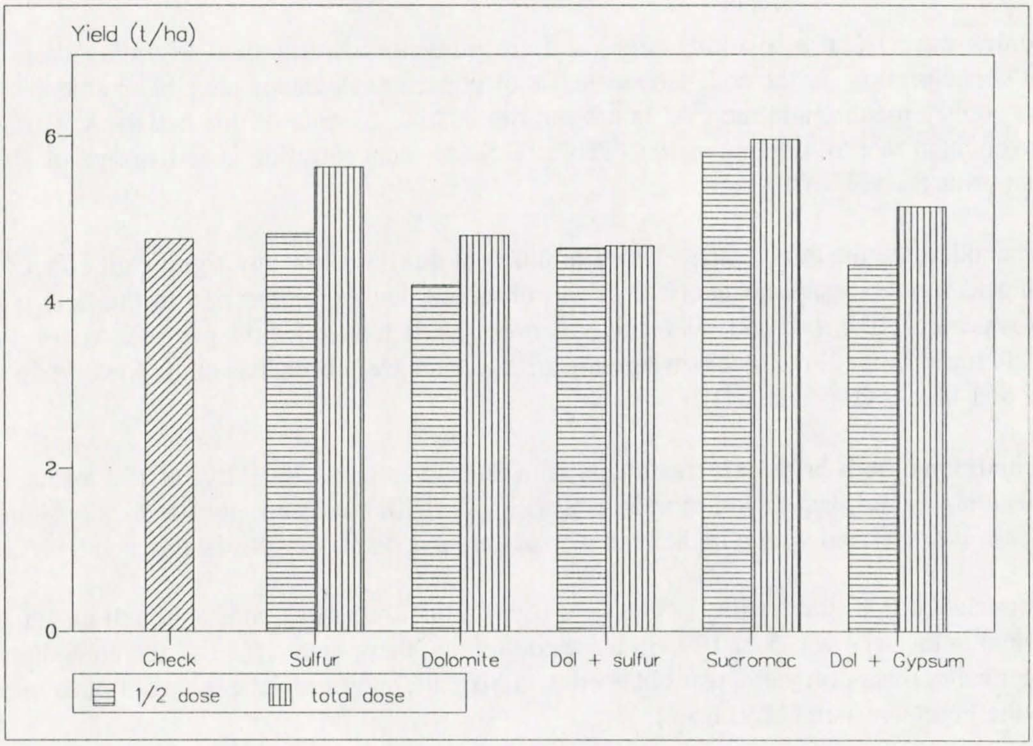

Fig. 1: Average yield of broadcasted treatments. Pescador 1996B.

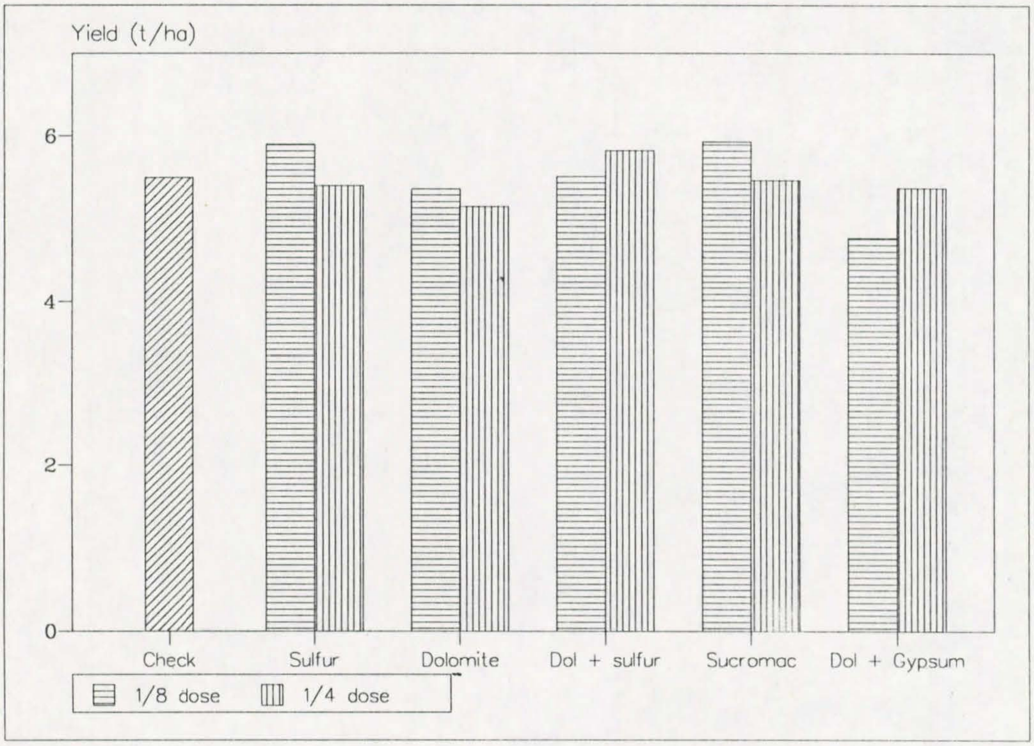

Fig. 2: Average yield of band placed treatments. Pescador 1996B.

Discussion:

Soils samples were taken at planting time, and amendments were applied assuming there was a high aluminum concentration in the soil. However, fields chosen at Pescador have been amended for several years with poultry manure and their Al saturation rate is low. In spite of this fact the soils remain acidic, with relatively high rate of organic matter (Table 1). Sulfur concentration is at average of 70 ppm much higher than critical level of 10 ppm.

With these conditions, the amendments tested in this trial did not show any significant effect (Table 2 and 3). Only blocks showed a significant effect. It was observed that the higher part of the field is more fertile because it is nearer to the road and has received more organic matter for the previous years. For the same reason, yield mean of the three blocks where the amendments were broadcasted, is lower than the mean of the three other blocks (Fig. 1 and 2).

In these conditions, both broadcast treatments with Sucromac and with sulfur at 152 kg/ha, have shown grain yields a bit higher than the other treatments (Fig. 1). Differences are not statistically significant. This yield increase is correlated with a higher number of ears per plant, but this is also no significant.

It can be concluded that the fertility of the field used in this trial was good, although its pH level is low. Average yield in this trial was 5.22 t/ha. In these conditions, there is no effect of the amendments applied. On the other hand, this grain yield was obtained with Sikuani, and proofs the interest of this open pollinated variety in the Pescador area (1850 masl).

3. Response to PxK interactions of three CIMMYT maize varieties and one hybrid. Carimagua, 1996 B.

Objective: To measure residual effects of fertilizers applied one year before, in 1995. The initial goal of the trail was to observe if it exists varietal differences for phosphorus or potassium efficiency between varieties created by the CIMMYT Cali program.

Treatments:

4 varieties	4 P levels (kg P_2O_5 /ha)	4 K levels (kg K_2O /ha)
Sikuani	0	0
Cimcali 93SA3	40	40
Cimcali 93 SA6	80	80
Hybrid H2	120	120

Trial management:

Design: Slpit-criss-cross, whith phosphorus and varieties crossed as main, and potassiun as sub-blocks.
Replications: 3
Plot size: 4 rows of 5 m longs, 2 center rows were harvested (8.25 m²)
Sowing distances: 0.75 x 0.50 m, 2 plants per hill. Expected plant number: 44
Fertilizers: treatments plus 120 kg/ha N in 1995, none in 1996
Sowing date: August 7, 1996
Harvest date: December 5, 1996

Seasonal meteorology:

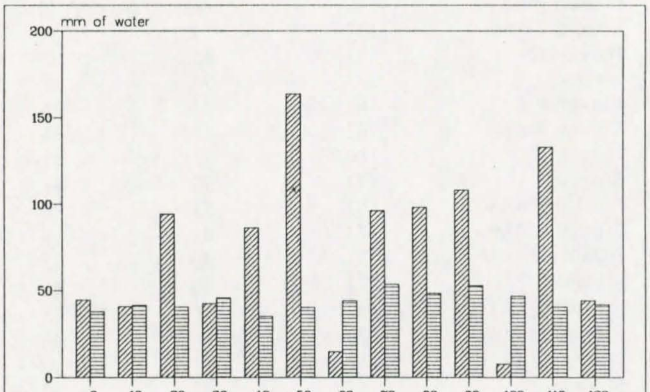

Fig. 1: Ten day rainfall and evaporation during the growing period

Results:

Table 1: Means of the 64 treatments of the trial Varieties x K x P levels. Carimagua 1996B.

K kg/ha	P kg/ha	Variety	Plt hgt.	Ear hgt.	Plants harvested	Yield t/ha	Ears/plt
0	0	Sikuani	150	47	41	1.50	0.57
		Cimcali 93SA3	160	37	37	1.51	0.75
		Cimcali 93SA6	147	38	34	1.59	0.77
		Hybrid H2	145	42	35	1.82	0.78
	40	Sikuani	173	44	41	1.93	0.67
		Cimcali 93SA3	172	55	34	2.02	0.87
		Cimcali 93SA6	147	37	37	1.78	0.70
		Hybrid H2	153	48	36	1.73	0.84
	80	Sikuani	150	48	39	1.96	0.61
		Cimcali 93SA3	160	53	36	2.36	0.94
		Cimcali 93SA6	142	42	33	2.15	0.74
		Hybrid H2	155	50	35	1.86	0.94
	120	Sikuani	175	53	40	1.68	0.88
		Cimcali 93SA3	167	57	38	2.51	1.00
		Cimcali 93SA6	167	43	41	2.24	0.79
		Hybrid H2	155	52	34	2.02	0.91
40	0	Sikuani	155	45	39	1.29	0.56
		Cimcali 93SA3	155	40	35	1.44	0.75
		Cimcali 93SA6	152	32	37	1.21	0.52
		Hybrid H2	143	42	35	1.80	0.79
	40	Sikuani	160	55	36	2.03	0.69
		Cimcali 93SA3	160	48	39	1.82	0.85
		Cimcali 93SA6	173	45	38	1.87	0.72
		Hybrid H2	170	55	34	2.25	0.91
	80	Sikuani	170	65	38	2.15	0.77
		Cimcali 93SA3	163	58	39	2.36	0.82
		Cimcali 93SA6	165	48	40	2.41	0.75
		Hybrid H2	173	57	26	2.44	1.03
	120	Sikuani	157	57	40	3.03	0.82
		Cimcali 93SA3	165	58	39	2.66	0.86
		Cimcali 93SA6	153	48	41	2.96	0.84
		Hybrid H2	170	55	36	2.81	0.93
80	0	Sikuani	143	47	35	1.29	0.75
		Cimcali 93SA3	140	40	34	1.38	0.77
		Cimcali 93SA6	137	35	34	1.55	0.86
		Hybrid H2	137	42	29	1.61	1.04
	40	Sikuani	177	58	38	1.84	0.69
		Cimcali 93SA3	165	55	36	2.18	0.88
		Cimcali 93SA6	162	42	35	1.70	0.80
		Hybrid H2	160	52	31	2.12	0.88
	80	Sikuani	177	57	41	2.20	0.67
		Cimcali 93SA3	162	57	34	2.84	0.96
		Cimcali 93SA6	170	45	38	2.40	0.70
		Hybrid H2	172	50	32	1.77	1.01
	120	Sikuani	172	60	36	2.07	0.73
		Cimcali 93SA3	162	57	35	2.80	0.92
		Cimcali 93SA6	170	47	32	2.40	0.79
		Hybrid H2	168	57	24	2.14	1.04
120	0	Sikuani	153	43	37	1.22	0.66
		Cimcali 93SA3	155	37	32	1.47	0.76
		Cimcali 93SA6	143	35	28	0.83	0.69
		Hybrid H2	138	43	28	1.85	0.96
	40	Sikuani	167	57	33	2.42	0.84
		Cimcali 93SA3	157	53	34	2.24	0.90
		Cimcali 93SA6	152	47	26	1.74	0.75
		Hybrid H2	155	48	31	2.12	0.99
	80	Sikuani	168	62	38	2.23	0.73
		Cimcali 93SA3	173	55	39	2.38	0.87
		Cimcali 93SA6	157	52	25	1.65	0.86
		Hybrid H2	157	60	36	2.78	0.98
	120	Sikuani	173	62	30	1.89	0.85
		Cimcali 93SA3	177	53	37	2.31	0.84
		Cimcali 93SA6	177	43	28	2.22	0.88
		Hybrid H2	167	53	25	2.28	1.02

Table 2: Means for the potassium and phosphorus levels and varieties. Carimagua 1996B.

Treatments	Yield (t/ha)	Plant hgt (cm)	Ear hgt (cm)	Plants number	Ears/plant
Potassium (kg/ha)					
0	1.92	157	47	37	0.80
40	2.16	162	51	37	0.79
80	2.02	161	50	34	0.84
120	1.98	161	50	32	0.85
Phosphorus (kg/ha)					
0	1.46 c	147 b	40 b	34	0.75 b
40	1.99 b	163 a	50 a	35	0.81 ab
80	2.25 a	163 a	54 a	35	0.84 a
120	2.38 a	167 a	53 a	35	0.88 a
Varieties					
Sikuani	1.92	164	54 a	38 a	0.72 c
Cimcali 93SA3	2.14	162	51 a	36 a	0.86 b
Cimcali 93SA6	1.92	157	42 b	34 ab	0.76 c
Hybrid H2	2.09	157	50 a	32 b	0.94 a

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares of the recorded data of the trial Varieties x K x P levels. Carimagua 1996B.

Source	df	Yield (t/ha)	Plant hgt (cm)	Ear hgt (cm)	Plants number	Ears/plant
Reps	2	0.36	164.19	20.26	445.70	0.012
Potassium	3	0.50	169.28	159.01	326.87	0.044
Pooled error 1	6	1.60	881.73	144.94	428.25	0.030
Phosphorus	3	7.89***	3758.46***	1905.12***	8.57	0.145**
Phosphorus x Potassium	9	0.45	499.78	61.25	39.68	0.023
Pooled error 2	24	0.31	246.09	73.81	34.70	0.023
Varieties	3	0.64	542.14	1124.70***	321.55**	0.479***
Varieties x Potassium	9	0.39	242.26	33.89	66.11	0.016
Pooled error 3	24	0.29	321.75	51.72	61.41	0.024
Phosphorus x Varieties	9	0.29	88.98	30.19	19.32	0.013
Var x P x K	27	0.13	107.61	25.80	20.53	0.011
Pooled error 4	72	0.27	147.16	43.24	20.10	0.016

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

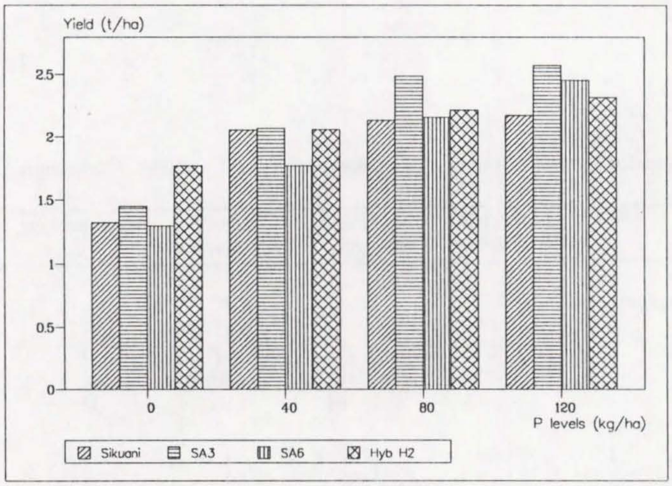

Fig. 2: Average yield of each variety at different level of phosphorus applied in 1995. Carimagua 1996B.

Discussion:

In 1996, no fertilizers were applied in this trial. Thus, results of this season were a residual effect study of all the chemical inputs. Significant effects of phosphorus applied in 1995 were still registered during this second year, in spite of the low yield level. (Tables 1, 2 and 3). The lack of nitrogen application can partly explain the low yields and also, as it can be seen in Fig. 1, a water shortage occurred at flowering time, 60 days after sowing.

Data of 1996, confirmed that phosphorus is a main limiting factor at Carimagua, and had a significant residual effect on plant and ear heights, number of ear per plant and yield (Table 3).

Significant differences are found between varieties for ear height, number of ear per plant and plants number in plots, but not for yield.

No interaction were found in 1996, when there was a significant phosphorus x potassium interaction in 1995. No significant phosphorus x variety interaction was found neither in 1995, nor in 1996. In 1996, the hybrid yielded a better than other varieties when no phosphorus was applied (Fig. 2). However, this last result was not statistically significant.

4a. Response of two varieties to density increase when growing in acid soil conditions. La Libertad, 1996 B

Objective: To draw the response curve of Sikuani to density variation. To compare forage production of Sikuani to a local variety one, when grown in acid soil.

Treatments: Varieties: Sikuani and Clavito

Densities:	0.75 x 0.26 m, 1 plant per hill	51 128 plants/ha
	0.75 x 0.20	66 666
	0.75 x 0.17	78 431
	0.75 x 0.14	95 238
	0.75 x 0.12	111 111

Trial management:
Design: Split-plot with densities as main and varieties as subblocks.
Replications: 3
Plot size: 5 rows of 10 m long, 3 central rows were harvested (variable area).
Sowing date: October 21, 1996
Harvest date: February 18, 1997
Amendment: 1.5 t/ha dolomite, applied 3 weeks before planting
Fertilizers: 90 kg/ha N, 20 kg/haP, 50 kg/ha K, applied as urea, TSP and KCl

Seasonal meteorology:

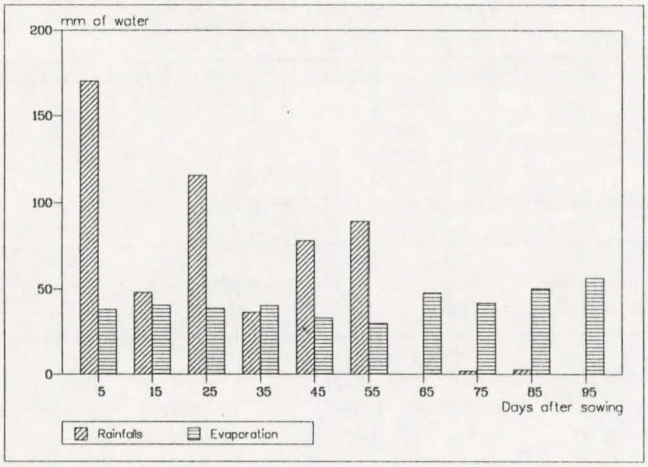

Fig. 1: Ten days rainfall and evaporation during the growing period

Results:

Table 1: Soil analysis before planting

Depth (cm)	% M.O.	ppm P Bray II	pH	Al (meq / 100 g)	Ca (meq / 100 g)	Mg (meq / 100 g)	K (meq / 100 g)	Al saturation %	S ppm
0-20	4.4	8.5	4.2	2.92	0.44	0.16	0.11	80	1.5
-20	3.0	2.8	4.1	2.90	0.27	0.10	0.06	87	9.5

Table 2: Chemical analysis of ear leaves taken in plots with 51 000 plants/ha. La Libertad 1996 B.

	P	K	Ca	Mg	S	Al
			%			ppm
Sikuani	0.24	2.12	0.36	0.25	0.17	143.33
Clavito	0.2	2.68	0.37	0.25	0.17	136.33
S.D.	0.04	0.27	0.03	0.03	0.05	8.57
C.V. %	17.3	11.3	9.5	13.2	26.5	6.1

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Means of main data for the both varieties and densities. La libertad 1996B.

	Average plant density	Male flowering (DAS)	Plant hgt (cm)	Ear hgt (cm)	Total dry matter yield (t/ha)	Grain yield (t/ha)	Samples of 10 plants per plot	
							Total dry matter (g)	Grain dry matter (g)
Sikuani	42607	58.33	195.00	100.00	4.76	1.58	979.00	435.67
	59777	58.67	186.67	86.67	4.53	1.35	757.33	317.33
	67451	59.00	191.67	91.67	4.59	1.12	695.00	283.33
	83897	59.00	186.67	88.33	5.10	1.18	515.33	176.33
	93704	59.00	186.67	91.67	5.28	0.95	520.67	219.67
Clavito	43629	62.33	220.00	150.00	3.83	0.15	593.00	35.33
	59555	62.67	235.00	153.33	3.98	0.11	565.67	56.33
	60915	62.67	233.33	151.67	3.94	0.07	645.33	18.67
	77859	62.67	233.33	153.33	3.82	0.07	500.00	9.33
	91852	63.00	226.67	151.67	3.63	0.05	485.67	1.33

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 4: Mean squares of main data of the trial on densities. La Libertad 1669B.

Source	df	Male flowering (DAS)	Plant hgt (cm)	Ear hgt (cm)	Total dry matter yield (t/ha)	Grain yield (t/ha)	Samples of 10 plants	
							Total dry matter	Grain dry matter
Total sub block	5	39.17	2683	5536	2.03	2.00	37884	105875
Varieties	1	112.13	12200*	27300***	7.67*	9.82***	137769	515878**
Blocks	2	20.93	7	175	0.78	0.08	2776	4678
Pooled error 1	2	20.93	600	15	0.46	0.02	23049	2069
C.V. %		7.5	11.7	3.3	15.7	21.8	29.3	24.3
Total	29	6.89	650	1021	0.68	0.41	50689	27318
Densities	4	0.38	34	21	0.06	0.12	89851	20031
Varieties x densities	4	0.05	127	63	0.31	0.06	36679	11278
Total sub-block	5	39.17***	2683***	5536***	2.03**	2.00***	37884	105875***
Pooled error 2	16	0.14	300	100	0.51	0.08	49152	8601
C.V. %		0.6	8.3	8.2	16.4	41.7	59.7	35.4

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

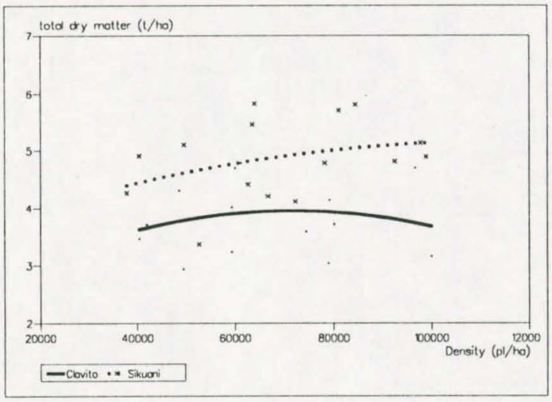

Fig. 2: Total dry matter production of Sikuani and Clavito depending of plant density.

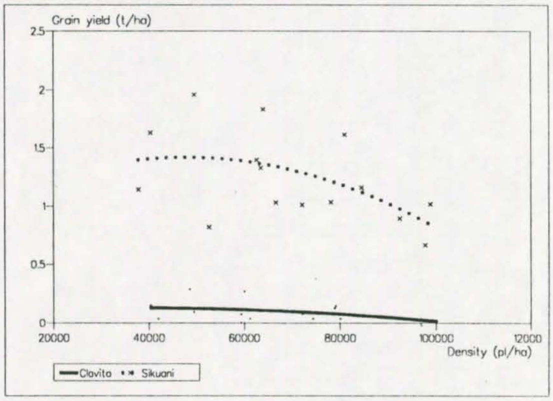

Fig. 3: Grain yield of Sikuani and Clavito depending on plant density.

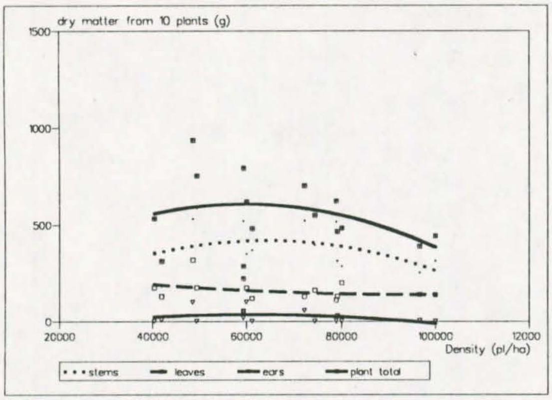

Fig. 4: Dry matter production of 10 plants of Clavito depending on plant density inside the plot.

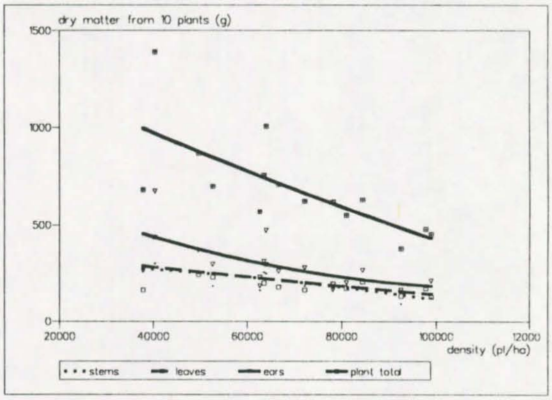

Fig. 5: Dry matter production of 10 plants of Sikuani depending on plant density inside the plot.

Discussion:

Yields were low, since total dry matter was about 5 tons/ha and grain yield 1.5 tons/ha for Sikuani (Fig. 2 and 3). The main reason of this result was the late sowing. Rainfalls stopped at flourishing time and plants have suffered water shortage during filling time (Fig. 1). Partly due to these low yields, results were indefinite. No statistical difference was recorded between density levels.Differerences were only recorded for varieties (Table 3). It can be seen on curves that Sikuani always produced more dry matter than Clavito, in spite of an apparent lesser growth, particularly in height (Table 1, Fig. 2 and 3).
In the conditions of this trial the grain yield of Clavito was nearly nothing. Clavito is a late maturiting variety and must have been stressed a lot by water shortage during the flowering and filling periods.

Components of dry matter have been studied on 10 plants per plot. Data showed that total dry matter production was more stable for Sikuani (Fig. 4 and 5). For Clavito, dry matter remained in stems since there were no ears produced.

Because of the low productivity, these curves will not be useful in conditions of better fertility. But they showed what happens in poor conditions.

4b. Response of two varieties to density increase when growing in acid soil conditions. Pescador, Cauca, 1996 B

Objective: To draw the response curve of Sikuani to plant densities. To compare forage production of Sikuani to a local variety, when grown in acid soil.

Treatments: Varieties: Sikuani and Yunga

Densities:		
	1.00 x 0.20 cm, 1 plant per hill	50 000 plants/ha
	1.00 x 0.15	66 666
	1.00 x 0.125	80 000
	1.00 x 0.105	95 238
	1.00 x 0.09	111 111

Trial management:
Design: Split-plot with densities as main, and varieties as subblocks
Replicatiosn: 3
Plot size: 9 to 10 rows of 3.5 m long, in 7 x 3.5 m plots. All plants were harvested.
Amendment: 1.5 t/ha dolomite, applied at planting time
Fertilizers: 90 kg/ha N, 20 kg/haP, 50 kg/ha K, applied as urea, TSP and KCl
Sowing date: October 10, 1996
Harvest date: March 13, 1997

Results:

Table 1: Soil analysis before planting

Plot situation	Depth (cm)	% M.O.	ppm P Bray II	pH	Al	Ca	Mg	K	Al sat. %	S ppm
					meq / 100 g					
Upper part	0-20	11.6	0.87	4.6	1.09	1.75	0.60	0.48	28	60.4
	20-40	7.8	0.25	4.6	0.67	1.23	0.34	0.31	26	49.4
Downer part	0-20	5.9	0.92	4.3	2.57	1.21	0.43	0.20	58	35.0
	20-40	4.3	0.72	4.3	3.60	0.90	0.30	0.15	73	18.8

Table 2: Means of main data for both varieties. Trial on densities. Pescador 1996B.

	Average plant density (pl/ha)	Ears/plant	Total dry matter yield (t/ha)	Grain yield (t/ha, at 15% humidity)	Samples of 10 plants per plot	
					Total dry matter (g)	Grain dry matter (g)
Sikuani	63741	0.58	4.30	1.99	827	353
	80612	0.69	4.60	2.44	801	314
	94625	0.65	4.33	2.21	751	322
	118027	0.55	5.18	2.21	542	190
	129319	0.47	4.86	1.91	357	101
Yunga	62108	0.61	6.15	2.93	1312	497
	80884	0.57	6.91	2.64	950	357
	102517	0.64	7.26	2.99	1093	447
	118231	0.51	6.89	2.73	835	311
	138843	0.43	5.43	1.88	485	113

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares of main data. Trial on densities. Pescador 1996B.

Source	df	Ears/plant	Total dry matter yield (t/ha)	Grain yield (t/ha, at 15% humidity)	Samples of 10 plants	
					Total dry matter (g)	Grain dry matter (g)
Total sub block	5	0.01	26.25	1.85	330663.50	48628.25
Varieties	1	0.01	26.30	1.75	58220300	59674.75
Blocks	2	0.01	46.13	3.02	36317575	66032.44
Pooled error 1	2	0.01	7.36	0.74	17088150	25700.81
C.V. %		17.2	48.5	35.9	52.0	53.3
Total	29	0.01	5.39	0.71	16699213	35266.94
Densities	4	0.04*	0.90	0.49	374120.56*	95684.89
Varieties x densities	4	0.00	1.14	0.24	3292019	5008.58
Total sub-block	5	0.01	26.65***	1.85*	330663.50*	48628.25
Pooled error 2	16	0.01	0.93	0.53	97713.19	23551.63
C.V. %		19.1	17.2	30.4	393	51.1

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

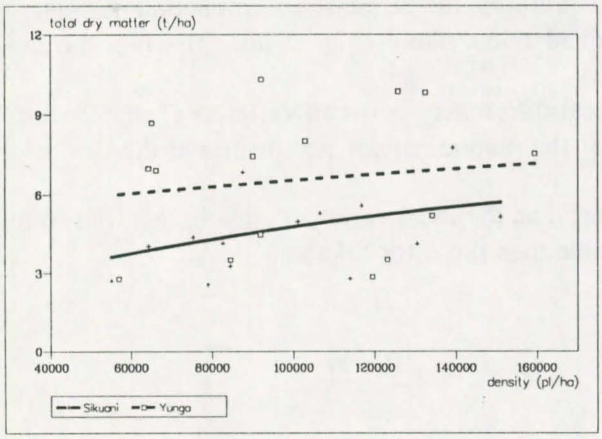

Fig. 1: Total dry matter production of Sikuani and Yunga depending on plant density in each plot.

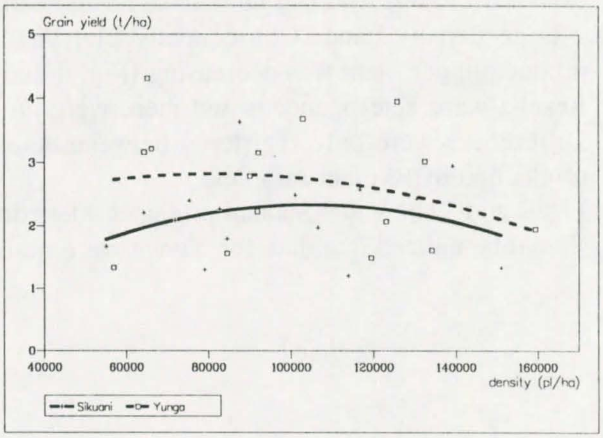

Fig. 2: Grain yield of Sikuani and Yunga depending on plant density in each plot.

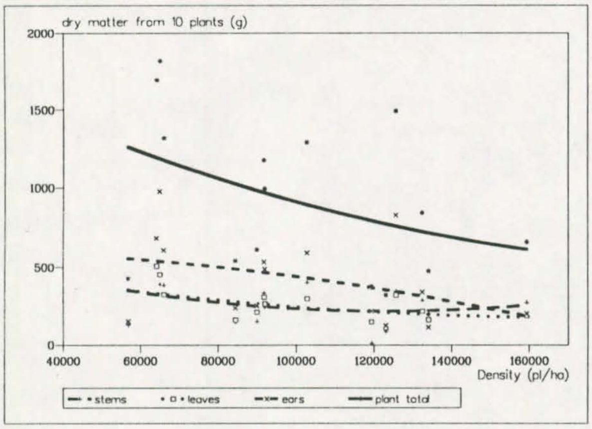

Fig. 3: Dry matter production of samples of 10 plants of Yunga depending on plant density in each plot.

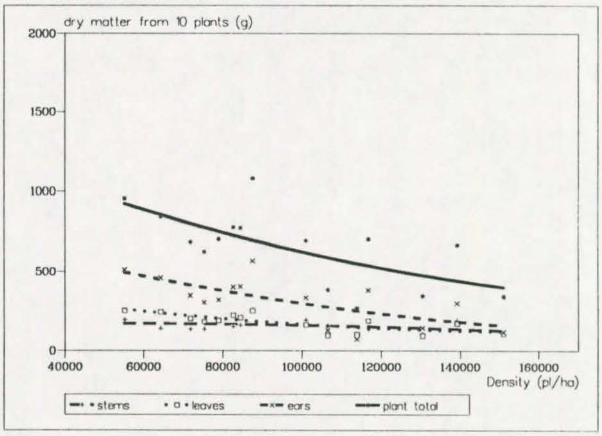

Fig. 4: Dry matter production of samples of 10 plants of Sikuani depending on plant density in each plot.

Discussion:

Yields were very low. Drought during the first three weeks of cultivation must partly explains these poor yields. In the trial planted ten days later at Pescador, not far from this one, growth and yield for Sikuani was better.

Soils samples were taken at planting time, and amendments were applied assuming that there was a high aluminum concentration in the soil. However, fields chosen at Pescador have been amended for several years with poultry manure and their Al saturation rate is low In spite of this treatment, the soils remain acidic, with relatively high rate of organic matter (Table 1).

Due to a false estimation of distances between the rows plowed with oxen, plant densities were higher than expected. In this trial,lant number of plants seemed to equilibrate the decrease of production per plant on a large density band. Consequently plot yield remained quite stable (Fig. 2 and 3) when the grain production per plant was decreasing (Fig. 4 and 5).

Results were heterogeneous and there were no statistical differences between varieties (Table 2 and 3). Differences were only registered between densities for the number of ear per plant and the dry matter production of 10 plant samples.

Fig. 2 and 3 show that Sikuani produces a less dry matter than the local variety Yunga in this trial. It also should be noticed that data for Yunga were more variable than those for Sikuani.